CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

Summer 2000 • Volume 11 • Number 2

Cornell's Turf Program Addresses Social, Economic and Environmental Issues

Turfgrasses represent one of the more important interfaces where people and plants come together, directly impacting the quality of human lives. Currently there are between 20 and 30 million acres of turfgrass in the United States, consisting of lawns, parks, golf courses, sod farms, industrial and institutional grounds, right-of-ways, etc. In New York State alone, close to two million acres are covered with turfgrasses. About 321,000 acres of residential and commercial lawns are managed by lawn and landscape services. Of that, approximately 50 percent lies in downstate New York (Westchester, Rockland, Nassau, and Suffolk Counties), where the landscape industry has traditionally been very strong.

The approximately 800 golf courses in New York State cover at least 80,000 acres of intensively maintained turfgrass, again concentrated throughout urban areas of the state. In addition, there are over 200,000 acres of highly maintained turf and lawns in parks, public and private institutions, schools, cemeteries, and airports. The rest of the two million acres of turfgrass are lower maintenance areas, such as highway medians and the residential lawns or commercial grounds not serviced by the lawn care industry.

The turfgrass industry, both nationwide and in New York State, continues to grow, with exponential growth in the golf course sector of the industry. This year in New York State alone, over $10 million will be spent on new golf course construction. Some courses under construction are being developed on former dairy, beef cattle, and cash crop land by owners hoping to secure a living producing a recreational commodity. In the landscape maintenance segment of the industry, sales have increased, but increased demand does not guarantee next year's profit.

Highly maintained turfgrass sites use vast amounts of inputs (fuel, fertilizers, pesticides, water for irrigation). Pesticide use in particular is greater than any other agricultural commodity produced worldwide. Many high-maintenance turfgrass sites are found in close proximity to surface waters and within critical

continued on page 4

This Times

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Editor: Frank Rossi

Illustrations: Kenn Marash, Barbara Raider

Design: Barbara Raider

Production: Ghostwriters, inc., Ithaca, NY

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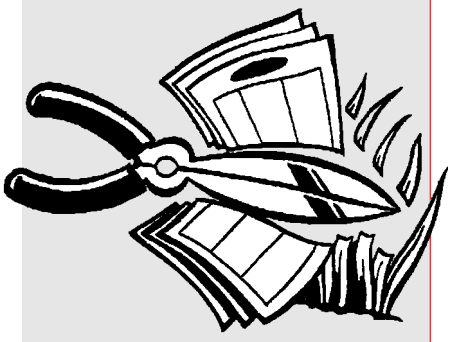
Clippings

The internet or mail based questionnaire would require about one hour of time to complete and examines how golf courses and associated management practices have evolved to relate to their surrounding environments and provide a better understanding about the relationship they maintain with surface and ground water bodies.



Fore! Golf Course Management Survey

Over the next few weeks, the turfgrass program at Cornell University will be hitting the links! However, rather than recovering from the sand and creating divots in your fairways, the Cornell team may be aiming for your participation in a study being conducted throughout New England and the tri-state area. Cosponsored by the New York State DEC, the fact-finding project seeks to identify current trends within the industry. The internet and/or mail based questionnaire would require about one hour of time to complete and examines how golf courses and associated management practices have evolved to relate to their surrounding environments and provide a better understanding about the relationship they maintain with surface and ground water bodies. Although some questions are asked about how pesticides are handled, this study is not concerned with pesticide use or the amounts they are used in. Roughly 600 golf courses will be contacted with a letter requesting participation. If selected, your commitment of time and information would be invaluable to providing an accurate projection about how golf course management practices are aligned to meet the challenges of future.

Managing our Natural Resources: The 2000 NYSTA Conference

The program is set for the New York State Turfgrass and Grounds Exposition scheduled for November 14 through 16, 2000 in Syracuse, NY. The theme for the 2000 conference continues NYSTA's commitment to environmental excellence, Managing our Natural Resources. Sessions consistent with this theme will include several basic and advanced topics on soils, water, fertilization, and wildlife management. In addition, as leaders in the area of sports turf education, we will be providing sessions on managing high traffic areas, core cultivation, and understanding the latest products on the market. As usual, the golf turf program continues to explore cutting edge research on environmental stress and how to identify and manage diseases such as gray leaf spot and bentgrass deadspot. Right in the middle of the conference, is the early bird session highlighting the latest research currently underway at Cornell on moss control, pesticide fate, dollar spot biology, and insect killing nematodes. The Tuesday Seminars will include grass and weed identification, as well as basic aspects of turf soil management, to help you get back to basics. As technology continues to enter the market, client expectations increase, and regulations limit our options, education is the key to maintaining a successful profession. I guess we'll see you in Syracuse!

Lawn Care and Water Quality Almanac Available

If you've ever wanted to provide information to your clientele regarding the impact of turfgrass management on water quality, which also explains the benefits of turf, when is the best time to fertilize, and how should a lawn be watered, then the almanac is for you. The almanac also lists common sources of stormwater pollutants, shows how to conduct a landscape water quality assessment, and has excellent photos and graphics of common lawn pests. The almanac is available from Media Services at Cornell University. You can access them at www.mediaserv.cornell.edu.

The Grass is Never Greener on the Other Side

Turfgrass entomologists may live above ground, but a lot of their grubby friends don't. Over 70 industry representatives, faculty, graduate students and extension specialists from around the country attended the "Turfgrass•Entomology•2000" conference at Cornell University's New York State Agricultural Experiment Station, in Geneva, NY, April 2-4, to talk about the grubs and other issues facing turf specialists and consumers. The meeting was hosted by Michael G. Villani, professor of entomology at Cornell, and Patricia J. Vittum, associate professor of entomology at the University of Massachusetts, Amherst.

"It was especially gratifying for us to meet at the Experiment Station because the turfgrass entomology community here has been considered one of the focal points of turf entomology

continued on page 15

Scanning the Journals

Researchers at the Center for Marine Science at the University of North Carolina—Wilmington, monitored 5 golf courses for nutrients and fecal coliform to determine discharge and how certain land use controls on golf courses such as buffer zones, wet detention ponds, and woodland wetland areas influence discharge.

Golf Courses Influence Water Quality

As the popularity of golf continues to grow and participation continues a slow steady climb, the need for new golf courses and demands on existing courses will increase. While many scientific studies have established the environmental benefits of golf courses as wildlife habitats and areas where water quality can be improved, few large scale monitoring studies have verified the water quality claims.

Researchers at the Center for Marine Science at the University of North Carolina—Wilmington, monitored 5 golf courses for nutrients and fecal coliform to determine discharge and how certain land use controls on golf courses such as buffer zones, wet detention ponds, and woodland wetland areas influence discharge. The fecal coliform was suspected based on the amount of wildlife that a course could sustain.

There were significant differences among the golf courses for nutrient discharge. For example, one course that had a designed drainage stream monitored, had high levels of nitrates in the middle of the course, but a final wet detention pond reduced the discharge from the site. Whereas, another course that had low nitrate levels in a stream on the course, had higher nitrate levels in the absence of a wet detention area prior to leaving the site. None of the courses had elevated fecal coliform levels, in fact most of the courses significantly reduced the levels that entered the site prior to discharge.

This study highlights the fact that much still needs to be learned at the landscape scale relative to golf courses and water quality. Several course had elevated levels of nitrate in the water on the course, that was not discharged. Why is this happening? Clearly, land use controls to exploit the biofiltering capacity of the landscape can be installed or retrofitted into golf course design.

From: Mallin, M.A. and T.L. Wheeler. 2000. Nutrient and fecal coliform discharge from coastal North Carolina golf courses. J. Env. Qual. 29:979-986.

Herbicide Increases Microbial Activity?

Concern over the use of pesticides in turf is often based on human exposure, influence on water and wildlife, and the influence on soil microbes. Conventional wisdom, as well as some scientific studies have found that herbicides significantly reduce microbial activity. Still, there are many questions regarding the measurement of microbial activity as well as the fact that many pesticides are carbon based molecules that require microbial degradation.

A study was conducted at Texas A & M University with glyphosate (Round-Up) applied to a silty loam soil at 1, 2, 3, and 5 times the recommended rate to investigate the influence on soil microbial activity and biomass. Interestingly, as glyphosate rate increased, the mineralization of carbon (C) and nitrogen (N) (a measure of microbial activity) increased and was significantly greater than the untreated plots for 56 days. Additional data indicated that the increased activity was directly related to addition of glyphosate. However, soil microbial biomass was not affected. Therefore, it appears that an insufficient amount of N and C was added to increase the number of microbes, however enough was available to increase activity.

As the genetically modified turfgrasses are introduced into the industry that are resistant to glyphosate, understanding the influence of this material on microbial activity is one of the many hurdles this technology will have to cross on its way to implementation. It appears that microbial activity is not a significant concern relative to glyphosate.

From: Hanney, R.L., S.A. Senseman, F.M. Hons, and D.A. Zuberer. 2000. Effect of glyphosate on soil microbial activity and biomass. Weed Science, 48:89-93.

Cornell's Turf Program

continued from page 1

groundwater recharge areas and are found primarily in and around the urban areas of the state in close proximity to most the population in the United States. Questions have been raised as to the impact of such a land use on water quality, wildlife, and human health, particularly as it relates to pesticide exposures.

Rationale for Increased Support:

A major goal of the Turfgrass Science Program at Cornell University is to develop management systems that promote environmental stewardship by reducing inputs of pesticides, fertilizers, fuel, and water, and to use materials (i.e., fertilizers, pesticides, growth regulators) that are safer to the environment and for human health. Cornell's turfgrass program is respected internationally as a program where strong science and outreach directly impact the ways in which environmental quality can be maintained. Private and public funds have been and will continue to be used to address important environmental issues in addition the development of systems to safely utilize waste materials (e.g., municipal biosolids, sewage effluent, composted industrial and agricultural wastes and byproducts) for the purposes of waste stream reduction and turfgrass management input reduction (i.e., water, fertilizers, and pesticides).

Positive social, economic, and environmental impacts would occur as a result of increased state funding by 1) enhancing preservation of green spaces in New York's urban environments and in protecting public health, 2) reducing costs of waste disposal and of turfgrass management inputs, and 3) on enhanced environmental protection and preservation.

The strength and size of the turfgrass industry nationwide and in New York—and their respect for the turfgrass program at Cornell—has created greater demands and presented more opportunities for the faculty and staff of the turfgrass program. It is becoming more difficult to not only meet the demands of the industry, but to take advantage of new opportunities and initiatives with the resources available to us. Clearly, the turfgrass program at Cornell is viewed as one of the leading programs in the country. Its effects are evident well beyond the boundaries of New York State. Information generated at Cornell is used in both research and education programs in all 50 states. It is essential that adequate resources be available to continue our important leadership role and continue to reach turf professionals, industry, and consumers with unbiased research-based information on the issues that affect their daily lives.

Additional support would be used to further strengthen research and outreach programs to reduce the impacts of turfgrass maintenance and production through increased 1) knowledge and use of microbial biotechnologies in pest control, 2) understanding of pest biology and ecology, 3) awareness and understanding of environmental contamination issues, 4) utilization of improved turfgrass varieties to reduce management inputs and potential environmental contamination, and 5) nutrient management efficiency.

State supported research, teaching, and extension programs will not only have measurable impacts on environmental quality in New York state, but will also be pertinent to other regions of the country. Despite our national and international influence, the outcome of these projects that impact the protection of drinking water quality, resource conservation, and reduced human health risks are intended for the residents of New York State. Even though the program has been fortunate to have support from industry/turfgrass management organizations such as the New York State Turfgrass Association, other funds are currently not and have historically not been available to fund such work. This is mainly because either the costs associated with the implementation of these programs have been too large, turfgrasses have not fit in the mainstream of agriculture, or for various reasons there has been a general lack of interest by legislators in funding such projects.

Rationale for State Support:

To meet the challenges ahead by continuing to enhance the development of research, teaching, and outreach programs, there is a need to expand our programmatic base within the turfgrass program. Currently there are 2.1 Full Time Eqivalents (FTE's) in research, 0.3 FTE's in teaching, and 1.55 faculty and 2.0 staff FTE's devoted to outreach. The overall research and educational strengths of the program have been in pest management, water quality, and allied environmental issues. We see an expan-

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sion of these efforts as essential to the continued growth and excellence of the Cornell turfgrass program.

Although all of the current faculty in the turfgrass program have been successful in securing outside funding to support research programs, base support for the maintenance of facilities is eroding. The Field Research Laboratory is now able to provide only the most basic level of support, is undersized, and poorly equipped to meet programmatic needs. Much of this support is coming from soft monies obtained by individual faculty. This is a potentially dangerous situation, limiting our abilities to solve some of the more pressing and immediate problems facing the industry. Furthermore, continuing reductions in both public and private support has made it difficult to maintain highly-trained technical personnel to support important research project and, in some cases, has halted productive research programs. Additionally, maintaining outreach programs has been hampered by insufficient funding to develop both human and other resources to support such programs.

The lack of a highly visible and structured turfgrass management curriculum at Cornell has had a negative impact on campus-based instruction in the turfgrass management discipline. A strong undergraduate teaching program is important to the overall well-being of the program. Not only does the program train students to serve the industry, but a strong base of alumni will support the program in the future. Certainly support is needed to increase the number of teaching FTE's in the program and to develop a plan for promoting the program.

In a time where the demand for education, information and service in support of the turfgrass industry has been overwhelming, the commitment from county extension associations for extension turfgrass programming has been limited. This has forced the turfgrass extension program to be increasingly campus-based. We do not see this trend reversing itself in the future. Therefore, additional resources are needed to maintain campus-based extension efforts.

Eric B. Nelson

Collaborating Organizations and Agencies; Teaching, Research and Extension Partnerships:

Federal Agencies: U.S. Department of Agriculture, U.S. Environmental Protection Agency.

National Organizations: United States Golf Association, Golf Course Superintendents Association of America, American Society of Agronomy, American Phytopathological Society, Entomological Society of America, Weed Science Society of America, International Turfgrass Producers Association, Professional Lawn Care Association of America.

State Agencies: New York State Department of Agriculture & Markets, New York State Department of Environmental Conservation.

Statewide Organizations: New York State Turfgrass Association, Tri-State Turfgrass Research Foundation, New York State Center for Advanced Technology, New York State Integrated Pest Management Program, New England Golf Course Superintendents Association, the eight regional Golf Course Superintendents Associations of New York State.

Industry Partnerships: Agricultural Chemical Companies, Waste Management Companies, Fertilizer Manufacturers, Seed Companies, Turfgrass Equipment Manufacturers.

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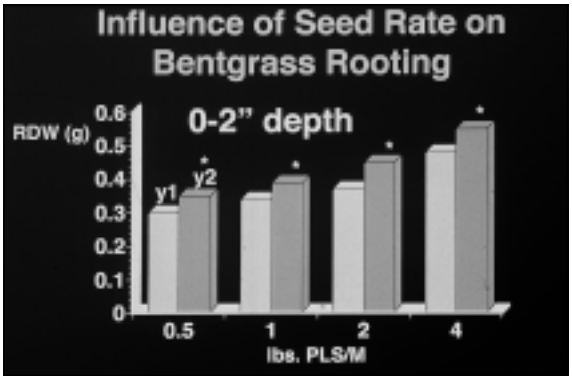
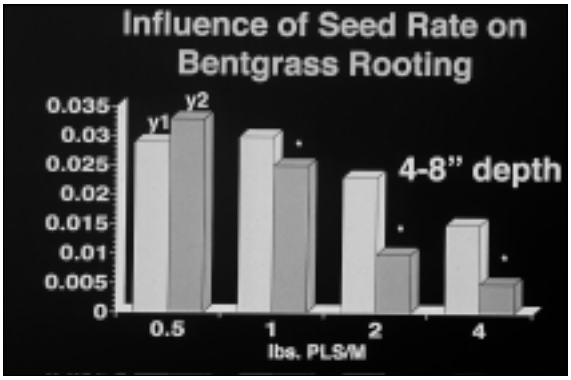
NYSTA Research Reports

The following reports are provided to NYSTA members as a means of keeping you informed of how your annual research grant monies are used.

Establishment Procedures Influences Seedling Survival, Morphology, and Rooting of Creeping Bentgrass

A study was conducted to evaluate golf putting green establishment procedures with four creeping bentgrass (*Agrostis palustris* Huds.) cultivars: Penncross, Penn A-4, L-93, and SR1119. Five seed rates were used (0.5, 1.0, 2, and 4 lb.) with five seed treatments: metalaxyl (Apron), *Pseudomonas aureofaciens*, *Azospirillum brasilience*, *Enterobacter cloacae*, and untreated seed. Seeding was undertaken twice, in June 1997 and August 1998. Seedling survival, morphology and rooting were examined.





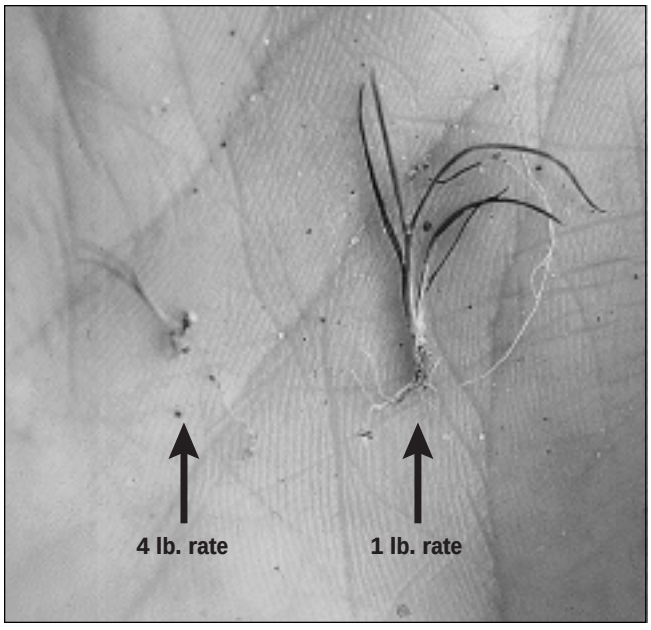
A sand (pH 7.8) putting green was constructed to "California" specifications. Data were collected in the establishment phase (up to 12 weeks after establishment) on seedling survival, visual cover and plant morphology. In addition, visual quality and root mass distribution data were collected the second season on the matured plots. Disease and drought occurrences were rated on both juvenile and mature turf.

Seed rate strongly influenced all measured parameters. Specifically, seed rate was inversely related to seedling survival and incidence of *Pythium* spp. Low seed rates produced in larger more prostrate plants All seed rates reached 90% visual cover by week 14. Overall root mass was greatest in high seed rates. However, the lower seed rates had greater root mass below four inches. High seed rates exhibited a greater degree of wilt symptoms than low rates during drought, most likely due to differences in deep root mass. Visual quality varied significantly between cultivars as management intensity increased on mature plots with Penncross consistently receiving the lowest rating.

This research provides compelling evidence in support of the importance of seed rate—independent of cultivar—for successful putting green establishment.

Frank S. Rossi

The influence of seed rate on seedling development.



Alternative Control Tactics for Black Cutworms in Turf

Black cutworms *Agrotis ipsilon* (Hufnagel) (BCW) are economically important pests of highly maintained turfgrass—both sod production and landscape turf—throughout the United States.

We evaluated alternative control agents (entomopathogenic nematodes, inorganic sulfur, insect growth regulators, and fungal pathogens) against black cutworm larvae using test products incorporated into standard artificial diets and more natural arenas using turfgrass as the cutworm food source and application target site. A secondary objective of this project was to develop a rapid and reliable assay system that would be easily replicated and allow activity measurements for cutworm fitness (larval and pupal weights) beyond simple mortality data.

Artificial diet bioassays involved the presentation of control agents in standard BCW wheat germ diet with weekly evaluation of larval mortality and development until pupation. Three insect growth regulators, slow release inorganic sulfur, the commercially-produced entomogenous nematode Hb Oswego, the fungal pathogen commercial formulation of *Beauveria bassiana* (Botani Gard), and the fungal pathogen, *Metarhizium anisopliae* were all evaluated against mid-instar cutworms at multiple rates. Insect mortality and weight in the various treatments were evaluated seven and twenty-eight days post treatment.

Our artificial diet results suggest that insect growth regulator products that tend to be quite selective in targeting pest species, are quite active at 7 days post treatment against black cutworm larvae at the labeled or anticipated field rates. Assays indicate a reasonable dose-dependent activity with increased mortality directly correlated with higher rate of product. Cumulative cutworm mortality and pupal weights at twenty-eight days appear to follow the trends described above for the insect growth regulators and inorganic sulfur treatments.

Entomopathogenic nematode treatment (Hb) showed excellent results in our diet assay indicating that the black cutworm is highly susceptible to the nematode species even at relatively low rates. However, because these nematodes must actively search for prey in turf, and they must survive possibly harsh environmental condition in the field these results do not translate into an expectation for comparable results in the field. The commercial fungal pathogen, Botani Gard did not produce cumulative mortality nor pupal weights that were significantly different than the untreated checks. Finally, *Metarhizium* grown in rice grains and placed on top of the diet cause high levels of mortality. This fungal isolate has also proven to be active against scarab grubs in laboratory and greenhouse bioassays.

Results obtained through the addition of test compounds to artificial diet, although easily replicated and useful for comparing levels of activity within a group of products or doses of an individual compound, may not reliably mirror field activity. Through a process of trial and error requiring several rounds of test bioassays our lab developed a protocol that provided low check mortality and reasonable reproducibility if assays were conducted sequentially through time, and provided a treatment substrate (grass clippings) that are the natural target against black cutworm products. Three insect growth regulators, inorganic sulfur, Hb nematodes, and the fungal pathogen Botani Gard were tested at a single rate.

Assessing larval mortality one day post treatment appears to provide little predictability on the ultimate activity of a product. Relatively few cutworm larvae died over the first 24 hours of this bioassay. Mortality at six days was uniformly high in the insect growth regulator treatments and relatively low in the sulfur and fungal pathogen treatments. These data are similar to the mortality levels observed in the artificial diet assays. The entomopathogenic nematode treatment showed highly variable activity. It should be noted that highly variable results are often observed in field and greenhouse bioassays using entomopathogenic nematodes

The mean larval weight of black cutworms one day post treatment was lower in most treatments than in the untreated controls. Larvae were observed down in the soil of these treat-

continued on page 15

NYSTA Research Reports

We hope that you find these research summaries informative. If you would like more complete information about the research, contact the Cornell Turfgrass Program at (607) 255-3090.

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NYSTA Research Reports

Our NYSTA-supported study was designed to evaluate the impacts of application scheduling on the disease control efficacy of introduced microbial inoculants.

Optimization of Application Timing and Frequency of Microbial Inoculants for Turfgrass Disease Control

Considerable information is now available concerning the use of microbial inoculants for the control of turfgrass diseases. However, despite positive experimental results, few microbial inoculants have been highly effective in field studies or in commercial use on golf courses.

A number of studies have shown that microbial agents perform most effectively when populations can be maintained at high levels, usually at populations exceeding 10^7 cells/g soil. However, applications made during the daytime hours may limit population development due to UV exposure or to desiccation. The limited number of success stories of biological control on golf courses have been from sites where applications of biological control organisms were applied during the overnight hours. Our NYSTA-supported study was designed to evaluate the impacts of application scheduling on the disease control efficacy of introduced microbial inoculants.

Intuitively, daily applications made during the evening hours should greatly enhance activity of microbial inoculants over conventional weekly applications or daily daytime applications since the overnight hours should provide more suitable conditions for microbial growth and activity and reduce mortality due to UV exposure and desiccation. Furthermore, applications would be made at the times when pathogens are most active.

Our results clearly show the potential for improving upon disease control efficacy of microbial inoculants by adjusting application schedules; moving away from traditional daytime applications on a two-week schedule to nighttime applications on a daily schedule. Our results have specifically shown that daily nighttime applications of various inoculants are superior to daytime applications or weekly applications. This response was also apparently independent of population level.

Our work in 1999 also focussed on the evaluation of a number of microbial inoculants for turfgrass disease control. Last season was a particularly tough season for disease control studies since temperatures were extremely high and rainfall was well below normal. As a result, disease development was not extensive and turfgrass stress was high. We essentially saw no dollar spot on the site where the liquid formulations were evaluated and no anthracnose on the adjacent site where the solid formulations were evaluated.

Following liquid applications, anthracnose severity remained relatively constant over the course of June and July with mean disease ratings ranging from 0.67 to 1.67. One week after the first application (June 17), plots treated with Roots+Bacteria A, Roots+Bacteria B, or Serenade at 10lb/A showed significantly lower levels of anthracnose than the non-treated plots. By the 24th of June (after two applications) only plots treated with Serenade at 10lb/A had significantly lower levels of anthracnose. For the remainder of the season no treatment provided significant levels of disease control. However, some responses are worth noting. On the last two rating dates, Daconil Ultrex failed to provide a significant level of anthracnose control throughout the season. Additionally, Roots Powder+Standup provided a significantly greater level of anthracnose control than other products such as Bio-A Plus, Companion, and RD-107.

Dollar spot incidence was observed relatively early on plots to which solid formulations of biological control products were applied. Through the month of July, dollar spot incidence remained constant. Slight increases were then observed by the August 23rd rating date. Many treatments were effective in reducing dollar spot incidence. All but GC-O and HHI-4 showed consistent levels of control through the latter part of the season (up until the last rating date). HHI-2 seemed particularly suppressive to dollar spot. Daconil Ultrex a significant level of control up to the last rating date. By the last rating date, only plots treated with the GC formulation showed a significantly lower incidence of dollar spot.

Eric B. Nelson, Michael P. Douglas, and Erica Deibert

Development of Alternative Weed Management Strategies in Landscape and Turf

The development of alternative weed management strategies in landscape and turf settings involves the use and implementation of novel biocontrol practices which can provide efficacious control over the course of the growing season.

Use of pathogenic organisms to control weeds has not proven particularly effective, due to problems in obtaining consistent control and difficulty in formulation of biocontrol organisms. Organically derived products, such as corn gluten meal, have also not provided consistent control, especially in commercial settings such as golf courses, parks and athletic fields where improved control is desirable.

One novel approach which shows strong potential is the selection, development and use of allelopathic or weed suppressive turfgrasses or groundcovers to naturally control annual weeds in the landscape, without the use of herbicides. Fescues, especially *Festuca rubra* spp., produce secondary products known as allelochemicals with potent ability to suppress weed seed germination and growth.

A collection of fescues was established as part of the NTEP trials at Cornell's turf farm. Quality and weed suppressive ability were evaluated in fall 1999 and spring of 2000. Of the 80 cultivars evaluated, five cultivars were identified that provided significantly greater weed suppression (>85%) when compared to other cultivars. In the laboratory, the same cultivars exhibit potent ability to suppress or kill crabgrass seedlings, even 2 weeks after fescue seeding. The chemicals produced by fescue seedlings which are responsible for growth inhibition in agar and sand cultures are currently under evaluation. Once the allelochemicals are isolated and identified, we plan to evaluate gene expression and isolate genes which are responsible for biochemical production of these inhibitors. This would be a highly valuable trait to incorporate into other less competitive turfgrasses.

In addition, an extensive literature search was conducted to select for groundcovers with known allelopathic or weed suppressive potential in the landscape. Drs. A. Senesac and Weston are currently propagating 40 different ornamental groundcovers which will be evaluated over a 3 year period for use in the landscape as far as stand establishment, aesthetic appeal and weed suppressiveness. Numerous species have been identified with strong weed suppressive potential. They will be established in both Ithaca at the Bluegrass Lane research facility and Long Island at the Riverhead research facility. A weed suppressive index will be determined for the materials under evaluation, based on growth measurements obtained. Recommendations will be developed for cultivar and species selection, seeding or planting rate and mowing heights for optimal management strategies of these ground covers and turfs to encourage maximal weed suppression.

Herbicides are also currently under evaluation for control of annual weeds in turf as well as turf growth regulation. Crabgrass control was evaluated in 1999 and 2000 using a variety of products. Due to drought in 1999, crabgrass germination was less consistent but numerous products were effective. Adjuvants were evaluated for use in control of annual broadleaf and grass weeds, to determine if organosilicon based surfactants provided improved control.

Our findings showed that under last year's difficult growing conditions, surfactants provided no additional postemergent activity of standard herbicides. Newly developed chemistry is also under evaluation for difficult to control species such as zoysia grass, and broadleaf weeds including veronica spp. and ground ivy. Zoysia grass control was not effective with early season application of ethofumesate which was reported to be effective in Georgia for zoysia suppression. Quinclorac was shown to provide effective suppression of veronica and ground ivy in mixed turf stands at all rates evaluated. Other studies with newly labeled products and products under development are underway in container ornamentals and field turf research plots.

Mugwort (*Artemisia vulgaris*) is a common perennial weed problem in turf and nursery plantings which is difficult to control, either culturally or with herbicide treatment. It propa-

NYSTA Research Reports

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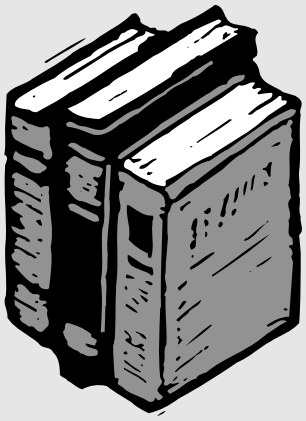
The Lawn Reader: Lawn Care Book Reviews

On the Bookshelf

Over the last year I have been on a mission to collect and read every lawn care book I could get my hands on at the major booksellers in the US, including web purveyors.



Each year Cornell Cooperative Extension, as well as the Extension System throughout the country receives hundreds of thousands of calls regarding lawn care. As a System, we have been effective in developing bulletins, fact sheets, and now even web-based information. However, this pales in comparison to the economic juggernaut of garden books that deal specifically with lawn care. But how do you know which ones provide the best information? And more importantly as a commercial turf manager, which one would I recommend to my clients that will give them a good overview of the subject so that we can speak intelligently.

Over the last year I have been on a mission to collect and read every lawn care book I could get my hands on at the major booksellers in the US, including web purveyors. What follows is my personal, objective review (where possible I state if otherwise) of almost 20 books currently available on the subject of lawns. I have confined my comments to first provide an overview of the text, then discuss its strengths and weaknesses, and finally highlight the key aspects worthy of further investigation. I have categorized the books into either 1) traditional lawn care or 2) lawn alternatives. If you are aware of any good ones that I missed, please don't hesitate to let me know.

Frank S. Rossi

Traditional Lawn Care Books

Smart Yard: 60 Minute Lawn Care
Jeff and Liz Ball
1996, Fulcrum Publishing, Golden, CO
ISBN 1-55591-138-2

A self-described approach as an "environmentally responsible, low maintenance" lawn care program, this easy to follow book provides and excellent overview of basic lawn care practices. It uses simple everyday language to convey some the scientific basis for why we do certain things to our lawns. The emphasis on "Soil Comes First" is well-intentioned, however, many aspects could have been explained more effectively by combining several chapters into this one. In addition, the lawn assessment and problem solving sections are weak with limited graphics to assist with identification of specific problems.

Building a Healthy Lawn: A Safe and Natural Approach
Stuart Franklin
1988, Garden Way Publishing, Pownal VT
ISBN 0-88266-518-9

This Williamsville, NY based landscaper has provided an extremely wordy guide to providing a "healthy lawn that is an environmental healer." This book is one of the most focused on an overall healthy approach without being preachy about organic or non-chemical practices. However, it is dated, lacking in the latest information regarding selecting endophytic grasses for insect control. In addition, it is written in a conversational style that for me was difficult to translate into what I should be doing for my lawn. There is an interesting section on criteria for selecting a commercial lawn care service that touches on "guidelines for the future" that seems prophetic.

The Impatient Gardeners Lawn Book
Jerry Baker
1987, Ballantine Books, NY
ISBN 0-345-34094-9

The self proclaimed, "America's Master Gardener," delivers a wildly entertaining, occasionally informative, and very dated lawn care book. Jerry Baker is an experienced gardener and salesman, filling the book with specific product recommendations based on his allegiance at the time. The book has several strengths worth noting such as, a complete list of recommended grasses for every state in the US, a list of State Extension Service publications, as well as generic weather information, a good question and answer section, and an excellent section on establishing a lawn that addresses many overlooked topics such as seed rate and rolling. Still, in his problem solving section, the constant rec-

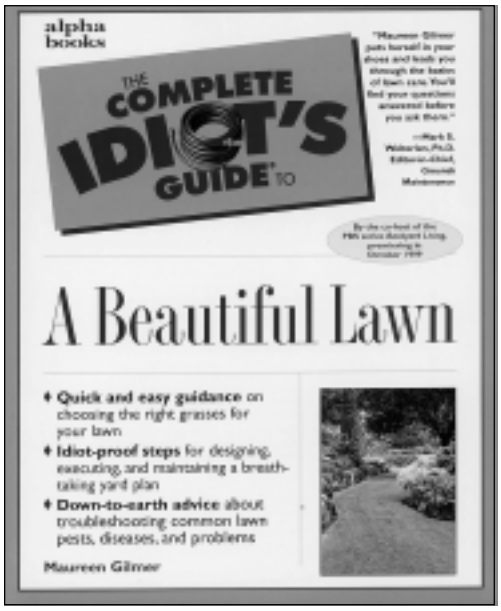
On the Bookshelf

"The Complete Idiot's Guide to a Beautiful Lawn" is easily one of the three best books on lawn care currently on the market today. Ms. Gilmer provides an excellent addition to the "Idiot's" series that is well organized, follows a logic flow and is filled with easy to read turf tips.

ommendation for beer, tobacco juice, or lawn shampoo borders on the ridiculous. I say this not only because his obsession with thatch is overhyped, but research using his concoctions found them to be no more effective than the more traditional methods found in an Extension publication. Clearly, these additions are entertainment related.

The Complete Idiot's Guide to a Beautiful Lawn
Maureen Gilmer
1999, Alpha Books, NY
ISBN 0-02-863008-4

Easily one of the three best books on lawn care currently on the market today. Ms. Gilmer provides an excellent addition to the "Idiot's" series that is well organized, follows a logic flow and is filled with easy to read turf tips. From the three most common myths about turf (pollution, clippings and water) to being a savvy seed shopper this book belongs on every lawn care provider's Christmas list for their customers. The only obvious weakness, as with many lawn care books, is the lack of a good diagnostic or problem solving section. The soil compaction chapter may be one of the best written, the pests sections are poor, lacking in graphics and providing limited options.



The 'New' Lawn Expert
Dr. D.G. Hessayon
1997, Sterling Publishers, NY
ISBN 0-903505-48-7

Another installment of the British "Expert" series is filled with graphical representation of practices that should make the process seem easier, yet it left me confused. Several sections provide excellent information on grass and weed identification. However, many UK-specific recommendations would be disastrous in the US. For example, the author suggests that optimum mowing height is 1" and there is little or no suggestion to have soil tested. Only 20 pages are actually devoted to lawn care with the remaining sections discussing equipment, pests, and lawn alternatives. This is one of the most common, yet weakest books on lawn care.

Lawns
Editors of Sunset Books and Magazines
1993, Sunset Publishing, CA
ISBN 0-376-03499-8

An 80 page booklet on lawn care that is very light on facts with little to no explanation of specific aspects of lawn care. While there are no mistakes in the text, it is written in a magazine article format that is easy to read but hard to connect into a lawn care program. Based in California, this booklet has the best irrigation chapter of any lawn book I reviewed from principles to practice; there is even a well outlined plan for installing an in-ground irrigation system. There are little if any problem solving sections and the pests sections do not provide good information on when you see certain problems.

Ortho's All About Lawns
Principal Writer: Warren Schultz
1999, Meredith Books, IA
ISBN 0-89721-421-8

A visually appealing addition to the Ortho series of garden booklets, filled with exceptional photographs and easy step by step procedures. One of the important strengths of this booklet is the availability of current grass variety and chemical recommendations. The lawn care section is a little bit of a let down, possibly because Monsanto does not have any products to sell in this area with the mowing, watering, and fertilizing section being fairly weak. That being said, the problem solving section is the best of any lawn book on the market. The photographs and graphical representations are exceptional

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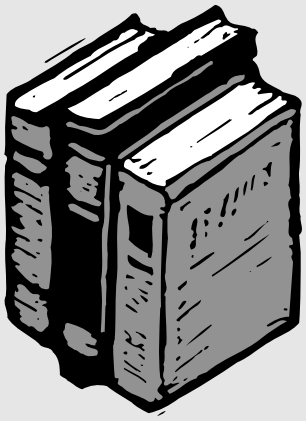
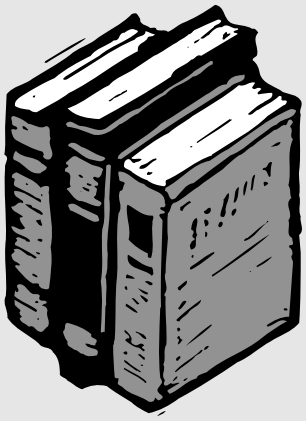


CUTT

On the Bookshelf

"Lawn Care for Dummies" is similar in many ways to the Idiot's Guide, in that it provides an easy to follow, well organized, and fact loaded format to get the "worst" gardener on the right track.



Lawn Care Book Reviews

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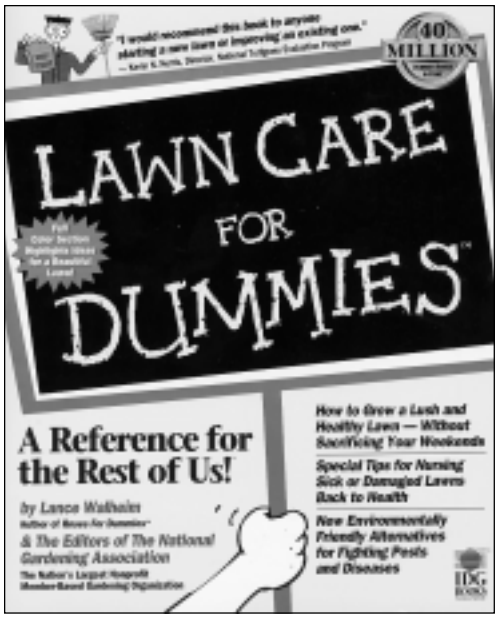


and many chemical and non-chemical options are provided. This is a must for lawn care providers providing IPM services for proper monitoring and identification.

Lawns and Ground Covers: How to Select, Grow and Enjoy
Michael MacCaskey
1982, HP Books
ISBN 0-89586-099-6

With only 50 pages devoted to lawn care, this terribly dated booklet does provide one of the best step by step descriptions of lawn installation using pictures. In addition, there is an excellent section on installing irrigation and the ground cover section appears to be thorough to the untrained (my own) eye. Still, there are so many other excellent texts for lawns and ground covers that this would not be one of my recommendations.

Down to Earth Natural Lawn Care
Dick Raymond
1993, Storey Communications
ISBN 0-88266-810-2

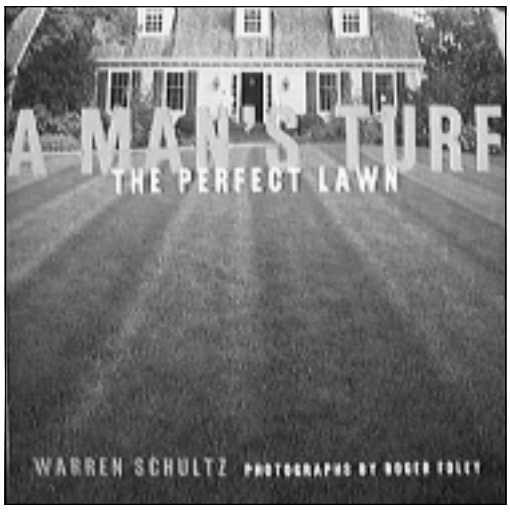
Dick Raymond's book is filled with folksy, old lawn care practices that just might be the solution to most homeowner's problems. In spite of the recent copyright date, much of the material seems dated and while the suggestion to eat dandelions rather than spray them seems goofy, Mr. Raymond does discuss various synthetic and organic options. One of the most useful sections for those hooked on the calendar type approach, is the seasonal guide that Mr. Raymond provides for each region of the country.

Lawn Care for Dummies
Lance Walheim
1998, IDG Books, CA
ISBN 0-7645-5077-2

This addition to the "Dummies" series is similar in many ways to the Idiot's Guide, in that it provides an easy to follow, well organized, and fact loaded format to get the "worst" gardener on the right track. The text is peppered with little tips and warnings while you learn the how and why of certain lawn practices, as well as easy to follow charts for selecting grasses to meet specific needs. The only drawbacks are the low quality graphics and the lack of pest control methods. However, the top ten lists at the back on drought, trees, games, etc. is worth the price of the book. This is one of the top three books on lawn care.

The Chemical Free Lawn
Warren Schultz
1996, Rodale Press, PA
ISBN 0-87857-801-3

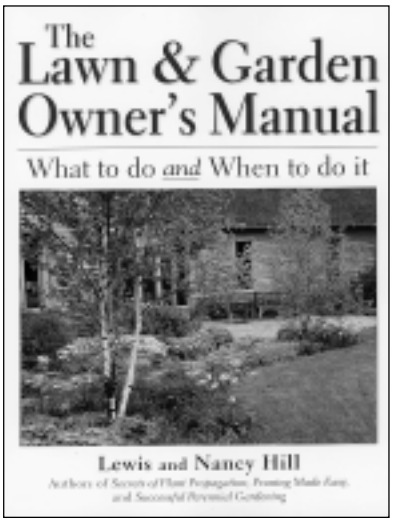
One of the most consistent and adept writers on the subject of lawn care, Warren Schultz takes a whack at developing a chemical free approach, and comes up way short. This book does not go into enough detail to help the homeowner truly understand the most effective methods to maintaining a healthy lawn. The weed section is especially odd, suggesting that completely defoliating dandelions, lower than the mower will go, 5-6 times will result in 92%



control; and completely omitting the use of corn gluten meal, an important organic option for preemergence weed control. This book exploits many people's interest in this topic and does not deliver the needed information.

The Lawn and Garden Owners Manual
Lewis and Nancy Hill
2000, Storey Communications
ISBN 1-58017-214-8

The most recent contribution from the Storey line of books is easily their best one yet. While this book does not devote much space to lawn care, for the avid gardener who generally disregards their lawn in favor of more elaborate and colorful aspects, the authors use their space wisely. The text begins with an overall garden calendar filled with timely lawn tips that are very current. The major weakness is the lack of explanation for how and why things are done that might help put things into context, however, as an overall garden resource this is one of the easiest to read and use.



A Man's Turf: The Perfect Lawn
Warren Schultz
1999, Crown Publishing, NY
ISBN 0-609-60068-0

The first coffee table book of lawn care, Schultz provides a excellent confluence of mechanical, scientific, spiritual, and historical perspectives. Do not expect to read this book and be capable of managing a lawn, however, you will be able to understand the role the lawn has played in the American psyche, as well as the enormity of the current turfgrass industry. The strength of this book is the photographs from Bogart mowing, to the groundskeepers at the old Yankee Stadium, and all the spectacular close-ups of the grasses. This is the perfect book for anyone obsessed with the lawn, like your local Extension Turfgrass Specialist. While not filled with too much practical information, it is my favorite lawn care book.

Handbook of $uccessful Ecological Lawn Care
Paul D. Sachs
1996, Edaphic Press, VT
ISBN 0-9636053-1-3

Paul Sachs, who also authored Edaphos: Dynamics of a Natural Soil System, has compiled and incredible amount of scientific information to support as close to an organic lawn approach as can be found. This book walks the line between textbook and popular writing, as it is filled with scientific references, but then explains them in an easy to understand style. This is the definitive factual guide for establishing a lawn ecosystem. The only weakness is that Paul does not lay it out for you, you have to develop a program for each individual site. I only say this is a weakness because the average homeowner would become frustrated, while the commercial turf manager should be able to develop an implementation plan. The second half of the book is devoted to the business aspects of lawn care that provides interesting perspective.

continued on page 14

On the Bookshelf

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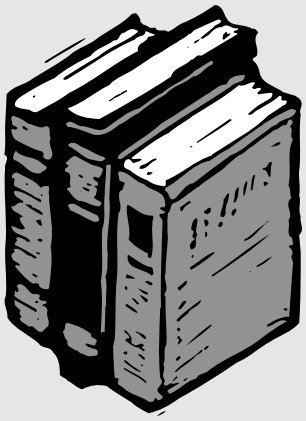
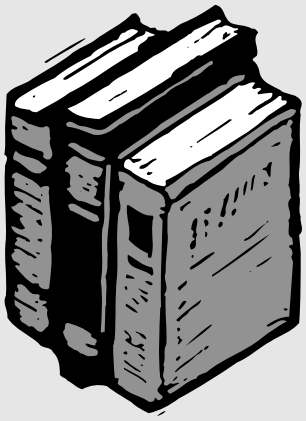


On the Bookshelf

"The Wild Lawn Handbook" takes the typical lawn bashing approach to launch what is otherwise one of the best lawn alternative books I have read. Stevie Daniels drew inspiration from leaders in the field such as Neil Diboll to provide an excellent resource for those wanting a wild lawn.



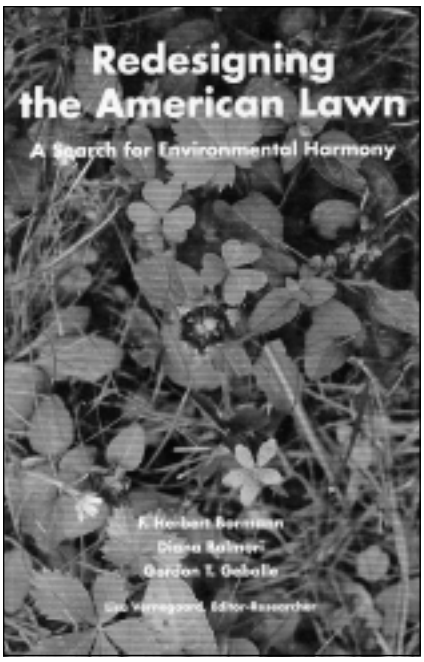
Lawn Care Book Reviews

continued from page 13

Lawn Alternatives

Redesigning the American Lawn: A Search for Environmental Harmony
F. Herbert Bormann, Diana Balmori, and Gordon T. Geballe
1993, Yale University Press, CT
ISBN 0-300-05401-7

This book was a collaborative venture between the faculty and students at Yale University. It was the result of a seminar series between the Art School and the School of Environmental Studies, focused on "The American Lawn". Simply, the interest of this book is to challenge whether the lawn, as a part of the American landscape, can be justified? The historical review suggests that we have a genetic predisposition to the perfect lawn from our ancestors that has evolved into the "Industrial Lawn" that receives chemical inputs. The book spends the majority of the space citing the environmental costs of lawns, with little practical suggestions besides just letting it go free, hence "The Freedom Lawn" that is only mowed. This is excellent reading to understand the position of environmental advocates against lawns. Unfortunately, it is one-sided.



The Natural Lawn and Alternatives
Janet Marinelli, Editor
1993, Brooklyn Botanic Garden, NY
ISBN 0-945352-80-8

This 90 page booklet provides a nice overview of non-chemical lawn care with few practical suggestions for putting it all together into a plan. The clear strength of this text are the lawn alternative sections, notably the Shade section by David Benner that highlights the use of moss with other shade tolerant plant material, and the Prairie section by Neil Diboll that reviews the basics of establishing a prairie. This is one of many BBG gardening guides that strives to motivate you to do more rather than specifically educate you on how to do it.

The Blooming Lawn: Creating a Flower Meadow
Yvette Verner
1998, Chelsea Green Publishing, VT
ISBN 1-890132-18-7

This book was written primarily for designing, installing and caring for a meadow in the United Kingdom, with only scant references to North American concerns. Nevertheless, it is a well compiled resource for those interested in taking an ecosystems approach to their property. There are wonderful resources for attracting wildlife and the lawn as a habitat. Since this text was born from the author's personal experience with establishing a meadow, my favorite section was the Meadow Calendar where she articulates the nuances and visitors to her meadow. It is a well written book, but do not expect to be more than motivated.

The Wild Lawn Handbook
Stevie Daniels
1995, Macmillan, NY
ISBN 0-02-529445-8

The author takes the typical lawn bashing approach to launch what is otherwise one of the best lawn alternative books I have read. She drew inspiration from leaders in the field such as Neil Diboll to provide an excellent resource for those wanting a wild lawn. The opening chapters on grasses and ground covers is the best chart I have seen that describes species in an easy to follow format. In addition, I found the case study approach effective in describing the challenges one would face when embarking on this type of venture. But clearly, the most entertaining section of the book is the Landscaping Ordinance Chapter. Several pages are devoted to how to establish or change laws that govern mowing requirements, virtually banning wild lawns in an urban setting. Many excellent resources are listed in the appendix.

Clippings

continued from page 2

since the 1940's through the research efforts of Dr. Gambrell, Dr. Tashiro, and myself," said Villani. The Station continues to be one of a small handful of institutions working on both fundamental and applied aspects of turf entomology.

"This is a national meeting and one of the most useful ones I go to," said Robert L. Crocker, associate professor at Texas A&M. Crocker's current project taping the sounds made underground by white grubs is a potential means of monitoring their numbers. "This meeting is a chance for us all to talk about environmental concerns, pesticides and alternatives to pesticides, to exchange new information on the ecology and biology of pest species, discuss new pests of turf, and talk about the effect of government regulations," he said.

During the meeting, the group also took the opportunity to celebrate the release of the second edition of *Turfgrass Insects of the United States and Canada*. Retired Cornell professor, Haruo Tashiro, who is considered the dean of American turfgrass entomologists, is the sole author of the first edition. Drs. Vittum, Villani and Tashiro are the authors of the second edition. A dinner was held in Dr. Tashiro's honor during the conference.

Seven topics were addressed during informative panel discussions over three days. In the discussion on biocontrol, moderators Jennifer Grant (NYIPM/Cornell), Albrecht Koppenhofer (Rutgers University), and Parwinder Grewal (Ohio State University) took a look at the practical use of biological control agents for controlling turfgrass pests. The use of biological insecticides, predators, and parasitoids for insect control in turf was also discussed.

In a panel discussion on the transition of IPM from research to implementation, moderator Fred Baxendale (Univ. of Nebraska), Rich Cowles (Conn. Agric. Exp. Sta.), and Gary Couch (NYIPM/Cornell) discussed moving IPM from the classroom to the field to the end user, integrating biocontrol and traditional approaches in a realistic IPM program, and the status of action thresholds and sampling in IPM programs.

In University/Industry/Government/Professional Relationships, moderator Rick Brandenburg (North Carolina State Univ.), Dan Potter (Univ. of Kentucky), and Chris Becker (American Cyanamid) talked about how funding shapes the message, whether roles, goals and responsibilities were clear, and how these relationships affect graduate education now and in the future.

Moderators Chris Williamson (Univ. of Wisconsin), and Wendy Gelerntner (Pace Consulting, San Diego CA) talked about advances in black cutworm management, from traditional and emerging control tactics to action thresholds and laboratory bioassays.

Pheromones and their use as attractants, arrestants and repellants was the focus of the session moderated by Paul Robbins (NYSAES/Cornell), Mike Klein (USDA/ARS.), and Robert Crocker (Texas A&M).

Emerging Environmental Issues, such as the impact of FQPA on turf insect pest management, selective vs. broad spectrum insecticides, homeowner use of products and local laws were addressed in a session moderated by Amy Suggars (TruGreen Chemlawn), David Cox (Novartis), and Gwen Stahnke (Washington State Univ.).

The Geneva Experiment Station continues to be one of a small handful of institutions working on both fundamental and applied aspects of turf entomology.

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Black Cutworm Control

continued from page 7

ments rather than feeding on the grass blades as observed in larvae feeding in untreated check replicates. Small cutworm larvae consume relatively large amounts of grass and grow rapidly during this period of their development. This weight disadvantage evaporates at the six day post treatment evaluation in the sulfur treatments (there is virtually 100% mortality in the growth regulator treatments). No weight loss was observed in the entomopathogenic nematode or fungal pathogen treatment at either evaluation.

Research conducted in this project has provided better understanding of the activity of products not currently under FQPA review against an important turfgrass pest. Additionally funding has allowed for the development of a novel and reliable screening assay that will but used to evaluate additional IPM compatible products in the future. Funding for this project was provided by the NYS Turfgrass Association and the NYS Community IPM Program.

Michael G. Villani

CUTT

How to Conduct Successful Employment Interviews

The Human Dimension

Five steps to a successful interview:

1) Prepare.

2) Greet the applicant and put them at ease.

3) Listen.

4) Encourage the applicant to ask questions.

5) Close with information about plans for making a decision.

The employment interview is the most common selection tool turf managers use when hiring new applicants. Success in interviewing depends upon preparation and proper execution of the interview process. An informal, unplanned interview process can easily lead to a selection mistake. In other words the wrong person gets hired. Following a few basic steps can increase chances that the interview process will be successful. In today's tight labor market, effort directed at attracting the right person for the job is well worth the extra time and effort.

Step 1

Step 1: Prepare. To prepare for the interview create a list of characteristics that are essential for job performance. Characteristics such as job knowledge mechanical skills, interpersonal skills and work habits can all be evaluated during the interview. Do not try to identify every possible characteristic that might relate to the job, instead choose four to six characteristics you think are most important.

Based on the characteristics you have identified write a list of questions that will elicit information that will help you predict the future job performance of the applicant. Use open-ended questions rather than questions that require a simple "yes" or "no" answer. Include in your list several probing questions that will help you find out as much as possible about the applicant. Figure 1 provides suggestions for questions that can be asked during the interview process.

Once you have developed a list of five to seven questions that are performance based it is important to use the list in each interview so that each applicant has the opportunity to answer the same questions. This formalizes the interview process and allows you to get the same information from each applicant. This step is critical to insure reliability in the interview process. It increases the chances that the right candidate will be chosen. Only by requesting the same information from each applicant will the interviewer be able to fairly compare each applicant.

The final step in preparation is to develop a rating system to score the answer to each question. A scoring system is extremely helpful when you attempt to summarize and interpret information from a number of interviews. For example, if you use a one to five scoring system and score the answer to each question you'll have a quantitative way to compare candidates after all have been interviewed. This process helps to formalize the interview and make it a better predictor of employee performance.

Step 2

Step 2: Greet the applicant and put them at ease. It is natural for a job applicant to be nervous at an interview. Obviously the more formal the interview the more relevant this issue is. It is important to make the applicant feel as comfortable as possible. The more you do to alleviate tension, the more meaningful the interview will be. A handshake, a friendly smile and possibly a tour of the work facilities are a good start. Make it a priority to find a quiet comfortable place for the interview to be conducted without interruption.

Step 3

Step 3: Listen. Open the discussion but encourage the applicant to do most of the talking. An interviewer who dominates the conversation or answers questions for the applicant will learn very little about the perspective employee. Ask open-ended questions that require an explanation rather than a "yes" or "no" response. With this technique the interviewer is likely to get the candidate to open up and provide more valuable information. Based on what the applicant says, make a note of any follow-up questions you want to ask later in the interview.

Step 4

Step 4: Encourage the applicant to ask questions. So far the applicant has been responding to questions. At this point the applicant should be encouraged to ask questions. Be

patient in allowing time for the applicant to get his or her questions formulated and asked. You should answer the applicant's questions in a straightforward manner. Be positive in describing your business and sell the position.

Step 5

Step 5: Close with information about plans for making a decision. Be specific about what happens next, when you will complete the interview process and when you plan to be in touch with the applicant. Be sure to follow through with all applicants.

When the interview process is completed assemble all of the information and make the best evaluation regarding who is most qualified for the job. Remember to resist personal biases and focus on job performance. Based on the interview, the application, reference checks and any other performance-based information make the final decision regarding who will be hired for the position. Using a planned systematic approach to the interview process is likely to lead to employment of the best possible candidate.

Thomas R. Maloney

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Figure 1.
Sample Interview Questions

This list of questions is intended to provide ideas for developing your own list of interview questions.

1. Job-Related Questions:

- What skills do you bring to a turf maintenance job?
- Can you work 6 a.m. to 3 p.m.?
- What experience have you had with mower operation and maintenance?
- Describe any formal education or training in horticulture.
- Describe work experiences from previous jobs that would be relevant to this job.

2. Probing Questions:

- What did you like most about your last job?
- What did you like least about your last job?
- How well did you get along with your supervisor and coworkers on your last job?
- Why are you looking for a new job?

3. General Recruitment Questions:

- What is your salary/pay expectation?
- When would you be available to start?
- Do you have any questions for me (us)?

continued from page 20

significant amount of nitrogen and other nutrients would be locked up by these microbes and would be unavailable to the plant roots. This is significant when we consider the fact that each millimeter cube (not meter!) of turf soil could potentially harbor 1 million or more bacteria.

Nematodes Help Unlock Nutrients

So how can the nitrogen locked up in microbes become available for plant uptake? That is where the primary consumers come in. The most abundant primary consumers in a healthy soil are the protozoa and tiny invertebrate animals such as nematodes (good nematodes!). The carbon-to-nitrogen ratio in animals such as nematodes is many times higher than that in bacteria, and so nematodes have a high demand for carbon. To get enough carbon, bacterial-feeding nematodes must consume many bacteria to satisfy their appetite for carbon. But since bacteria have a relatively high nitrogen (low carbon) content because of their highly proteinaceous nature, nematodes must excrete the excess nitrogen (usually as ammonia) that would otherwise build up to toxic levels in their bodies. The excreted ammonia is converted to nitrate, which becomes available for uptake by plant roots. Therefore primary consumers (nematodes, protozoa, tiny mites, etc.) that feed on microbes are necessary for the proper functioning of your turfgrass system.

Nematodes in turn become a food source for predator nematodes, small arthropods, and fungi that feed on nematodes. Thus in a healthy turf system, populations of microbes, nematodes and other soil inhabitants are kept in check naturally. It is important to note here that the soil ecosystem is far more complex than what you and I at this moment are attempting to visualize. Only a minute fraction of all the species of life forms in the soil ecosystem have been identified and characterized by scientists. However, the roles of many key players are known.

Free-Living Nematodes Up, Root-Feeding Nematodes Down

All turf systems will have at least one plant parasitic nematode species present. Plant parasitic nematodes poke many microscopic holes in roots and may cause significant leakage of plant cell contents when they feed on turf roots. In a healthy soil ecosystem with a well balanced community of predators, prey, and antagonistic microbes, proper organic matter decomposition, good soil structure/tilth and intact nutrient cycling processes, the number of root

Sampling turf for "good" nematodes.

A Healthy Ecosystem

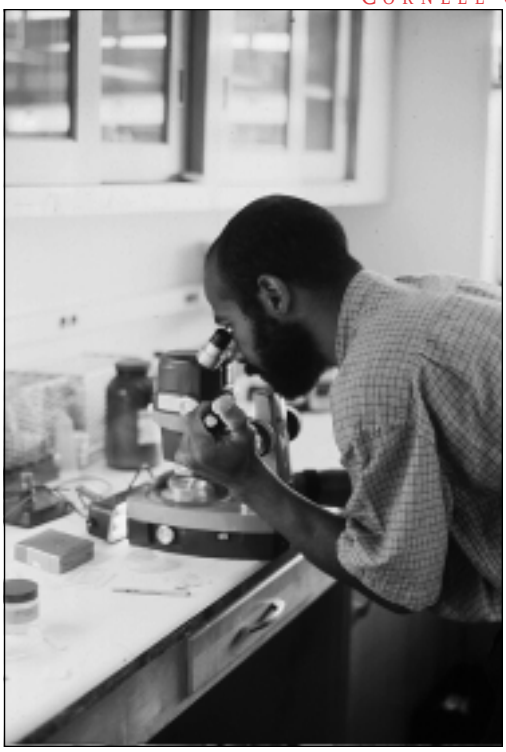
Therefore primary consumers (nematodes, protozoa, tiny mites, etc.) that feed on microbes are necessary for the proper functioning of your turfgrass system.

Only a minute fraction of all the species of life forms in the soil ecosystem have been identified and characterized by scientists.

punctures by plant parasitic nematodes will be at a minimum. A strong correlation may exist among the best plant responses, lowest numbers of plant parasitic nematodes and highest numbers of free-living (beneficial) nematodes. Organic matter decomposition products are thought to increase overall numbers of bacteria in the soil, which will increase bacterial-feeding nematodes that may cause increases in nematode-feeding fungi, which in turn do not discriminate and will feed on plant parasitic nematodes also. Infected or antagonized plant parasitic nematodes have decreased chances of puncturing, withdrawing or causing leakage of nutrients from plants. Leaky or punctured roots attract secondary fungi and bacteria that accelerate root rots or simply debilitate or predispose root systems. A compromised turf root system will not take up nutrients properly and will be more susceptible to invasion by pathogenic fungi and bacteria (which in fact are only a small minority).

Encourage All Types of "Good" Nematodes

Turfgrass managers need to encourage the buildup of free-living nematodes in their turf. They should attempt to maximize the ratio of beneficial to plant parasitic nematodes in their turf. Entomopathogenic nematodes, which are special types of bacterial-feeders, comprise only a tiny fraction of the beneficial nematodes in soil. In fact, entomopathogenic nematodes are parasites (of insects) and not free-living nematodes per se. Their survival depends on a selfish requirement to feed on "clean" bacteria inside an infected insect. However, an increase in all types of beneficial nematodes should be encouraged. Superintendents should request a count of the number of all beneficial nematodes in their turf when submitting samples to a lab for nematode analysis. Simply divide the number of beneficials by the number of plant parasitic nematodes to get a ratio for your turf. Separate samples should be taken from trouble spots and healthy-looking areas in mid-spring and mid-fall. One way turf managers inadvertently destroy beneficial nematode animals in their soil system is with applications of certain agrochemicals repeatedly or in high concentrations to the turf. If zero nematodes are counted in your soil sample, then your soil system is certainly unhealthy (for want of a better word). The health of the microbial population in your soil will be reflected in the status of free-living nematodes thriving in your turf soil ecosystem.



Extracted nematodes being studied in the laboratory.

Bioindicators of Soil Vitality

The presence of nematode animals in the turf soil system is a sign of soil vitality. Soil vitality (presence of beneficial animals) is indicative of good soil health. Because golf courses and lawns are not isolated systems like aquaria or indoor plants growing in a suitable potting mix, the need to maintain healthy soil ecosystems is an imperative (especially if we must protect contiguous ecosystems). One obvious signal or sign of trouble (degradation) would be the absence of beneficial nematodes or a preponderance of plant parasitic forms. Microbes are extremely important in healthy soil systems for capturing nutrients and forming humus. However, without 'predators' of microbes (for example nematodes, protozoa, etc.), a substantial portion of unleached nutrients immobilized by microbes may still not become available to plants in adequate amounts for growth.

Moreover, nematodes possess sensory nerves just like the ones in the human nostril and so these animals are very sensitive to changes in soil health status. Free-living nematodes therefore integrate or reflect the functioning of essential processes in your turf soil system. Because of the ubiquitous distribution of nematodes and their possession of sensory organs, we are using free-living nematodes in turf systems to give an early warning of potential environmental problems.

Joseph Esnard

If zero nematodes are counted in your soil sample, then your soil system is certainly unhealthy (for want of a better word). The health of the microbial population in your soil will be reflected in the status of free-living nematodes thriving in your turf soil ecosystem.

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Why Turf Needs "Good" Nematodes

A Healthy Ecosystem

Nematodes are complex, animalistic organisms, which possess organ systems (connected by nerve cells). The great majority of nematodes play beneficial roles in the soil ecosystem.

Do you know that terrestrial ecosys tems (which include turfgrass sys tems) would not function well without the right types of nematodes? Terrestrial ecosystems continue to function well as long as beneficial organisms are present in adequate numbers and at the right time in the web that supports these systems. The turfgrass soil system would function poorly if the right types of beneficial organisms were not present in optimum numbers. If the soil in the turfgrass system harbors the right balance and types of organisms (example bacteria, fungi, protozoa, nematodes, tiny arthropods including certain mites), only minimal input of fertilizer and other agrochemicals may be necessary for adequate management of the turfgrass. This would mean reduced costs associated with fertilizer and pesticide applications, fewer trips to the greens, and decreased probability of ground or drinking water contamination. One attribute of a healthy ecosystem would be the absence of negative impacts on adjacent systems (for example, streams and other contiguous aquatic systems).

Simple Bacteria to Complex Animals

The turfgrass soil ecosystem comprises essentially a microbe-animal-plant-soil aggregate system. The most abundant animals in the turfgrass soil ecosystem are nematodes. Bacteria and fungi are the most abundant organisms but they are comparatively simple life forms. Protozoa (for example amoebae, ciliates and flagellates) are next in complexity although still relatively simple (since they lack organ systems). Nematodes are complex, animalistic organisms, which possess organ systems (connected by nerve cells). The great majority of nematodes play beneficial roles in the soil ecosystem. Many feed on soil bacteria, while others feed on fungi. Still there are others that feed on other nematodes (predators) or those with no apparent specialty (omnivores). Only a minority of nematodes directly rob nutrients from plants.

Microbes Lock Up Nutrients

Plants, including grasses, have for millions of years thrived and protected themselves using a cooperative system that works well (without need for substantial fertilizer inputs). In that system, the most numerous and ubiquitous inhabitants (bacteria) possess elaborate enzyme (protein) systems that allow them to break down complex organic matter. These soil bacteria have a very high requirement for nitrogen to make proteins. Proteins essentially run the whole show in living things. If you ignored all components except the carbon and nitrogen that make up a bacterium, then about 1/6 or so of the bacterium would be nitrogen. This means that a lot of the nitrogen in organic matter or free nitrogen in soil solution is eventually locked up inside bacteria. Therefore, if your turf soil had only "good" microbes (and no other organisms such as nematodes and protozoa), a

continued on page 18

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CORNELL UNIVERSITY TURFGRASS TIMES
20 Plant Science Building
Cornell University
Ithaca, NY 14853